

INSTITUTE	FACULTY OF ENGINEERING AND TECHNOLOGY
PROGRAM	BACHELOR OF TECHNOLOGY (MECHANICAL ENGINEERING - ROBOTICS & AUTOMATION)
SEMESTER	3
COURSE TITLE	KINEMATICS AND DYNAMICS OF ROBOTS
COURSE CODE	01MR0302
COURSE CREDITS	4

Objective:

- 1 Develop the ability to model, analyze, and evaluate robotic systems using mathematical foundations, kinematics, and dynamics, including coordinate transformations, DH parameters, Jacobian methods

Course Outcomes: After completion of this course, student will be able to:

- 1 Apply vector algebra, coordinate transformations, and matrix operations to model robotic motion mathematically
- 2 Formulate and implement homogeneous transformation matrices for robotic systems.
- 3 Derive and solve forward and inverse kinematic equations of robotic manipulators using DH representation and coordinate systems.
- 4 Analyze robot orientation using Euler angles and RPY representations and solve inverse kinematics using geometric approaches.
- 5 Compute velocity and acceleration of robot joints and end-effectors using Jacobian-based methods and Dynamic analysis.

Pre-requisite of course:NIL

Teaching and Examination Scheme

Theory Hours	Tutorial Hours	Practical Hours	ESE	IA	CSE	Viva	Term Work
3	0	2	50	30	20	25	25

Contents : Unit	Topics	Contact Hours
1	Introduction Introduction Vector Representations and Operations, Transformations, Translational and Rotational, Coordinate Reference Frames, Properties of Transformation Matrices, Matrix Creation and Manipulation.	4
2	Robot Kinetics: Position analysis Robot Mechanism, Matrix Representation, Homogeneous Transformation Matrices, Inverse of Transformation of matrices, forward and inverse kinematics of robot.	6

Contents : Unit	Topics	Contact Hours
3	Kinematics Kinematic Parameters, The Denavit-Hartenberg (DH) Representation, Forward & Inverse Kinematic Equations: Position, Cartesian Coordinates, Cylindrical Coordinates, Spherical Coordinates, Articulated Coordinates.	14
4	Forward & Inverse Kinematic Orientation Description, Forward & Inverse Kinematic Equations Orientation, Roll, Pitch and Yaw (RPY) Angles, Euler Angles, Geometric Approach to Inverse Kinematics, Forward and Inverse Kinematics of Industrial Robot.	10
5	Velocity & Acceleration and Dynamic Analysis Differential Motions and Relationships, Forward and Inverse Velocity Analysis, Acceleration Analysis, Introduction to Dynamic analysis	10
Total Hours		44

Suggested List of Experiments:

Contents : Unit	Topics	Contact Hours
1	Experiment 1 Analysis of Robotic Motion Using Vector Representation and Fundamental Vector Operations (Addition, Subtraction, Dot Product, and Cross Product)	2
2	Experiment 2 To implement coordinate transformations (translation and rotation) between different reference frames using matrix representation.	2
3	Experiment 3 To develop and verify rotation matrices about X, Y, and Z axes and study their properties using software	2
4	Experiment 4 To formulate and analyze homogeneous transformation matrices for pure translation and pure rotation cases.	2
5	Experiment 5 To implement combined homogeneous transformations and study transformations relative to a moving coordinate frame.	2
6	Experiment 6 To analyze Forward Kinematics and validation using a software	2
7	Experiment 7 To analyze inverse kinematics of any real Robot and validation.	2
8	Experiment 8 To analyze orientation representation of robotic manipulators using Euler angles and Roll–Pitch–Yaw (RPY) angles.	2
9	Experiment 9 To compute the Jacobian matrix of a robotic manipulator and analyze joint and end-effector velocities.	2

Suggested List of Experiments:

Contents : Unit	Topics	Contact Hours
10	Experiment 10 To perform velocity and acceleration analysis of a robotic manipulator using Jacobian-based methods.	2
11	Experiment 11 To determine Denavit–Hartenberg (DH) parameters for a simple robotic manipulator and construct the DH table.	2
12	Experiment 12 To design and simulate a 3-DOF robotic manipulator, including: Forward kinematics, Inverse kinematics, Workspace visualization using software	2
Total Hours		24

Textbook :

- 1 Introduction to Robotics: Analysis, Control, Applications, Saeed B. Niku, 3rd Edition (Indian Adaptation), Wiley India, 2024
- 2 Introduction to Robotics, (ii) S. K. Saha, McGraw Hill Education (India) Pvt. Ltd, 2014

References:

- 1 Introduction to Robotics – Mechanics and Control, Introduction to Robotics – Mechanics and Control, John J. Craig, Pearson Education, 2004
- 2 Theory of Applied Robotics: Kinematics, Dynamics, and Control, Theory of Applied Robotics: Kinematics, Dynamics, and Control, Reza N. Jazar, Springer, 2010
- 3 Robot Kinematics: Forward and Inverse Kinematics, Robot Kinematics: Forward and Inverse Kinematics, Tuna Balkan, Intech, 2006
- 4 Robotics and Control, Robotics and Control, Mittal RK, Nagrath IJ, TMH, 2010
- 5 Robot Modelling and control, Robot Modelling and control, Spong Mark and Vidyasagar, Wiley India , 2008

Suggested Theory Distribution:

The suggested theory distribution as per Bloom’s taxonomy is as follows. This distribution serves as guidelines for teachers and students to achieve effective teaching-learning process

Distribution of Theory for course delivery					
Remember / Knowledge	Understand	Apply	Analyze	Evaluate	Higher order Thinking / Creative
0.00	0.00	45.00	35.00	20.00	0.00

Instructional Method:

- 1 Presentation
- 2 Animations

Supplementary Resources:

- 1 <https://archive.nptel.ac.in/courses/112/105/112105234>
- 2 <https://www.machinedesignonline.com/>